AUG 30 1945

Sky and TELESCOPE

Flash spectrum from 26,000 feet

Vol. IV, No. 11
SEPTEMBER, 1945
Whole Number 47
25 cents

In This Issue:

Sky and TELESCOPE

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Dr. Prager at a recent gathering of astronomers, photographed by Luigi Jacchia.

Richard Prager

PROFESSOR RICHARD PRAGER, research associate in astronomy at Harvard, died on July 20th, after a long illness. His loss will be felt throughout the entire astronomical world, especially as in his career he bore the burden of some of the science's long and tedious jobs.

The German astronomer, who became an American citizen about a year before his death, was born on November 30, 1883, in Hannover; he attended Marburg and Goettingen universities and received a Ph.D. from the University of Berlin in 1908, where he studied mathematics, natural science, and astronomy. Among his teachers were Bauschinger, Minkowski, Nernst, Planck, and Schwarzschild.

Dr. Prager became assistant at the Academy of Science in Prussia, where he worked on a history of the fixed stars. He served as chief secretary of the observatory in Santiago, Chile, from 1909 to 1913, returning to the newly built Berlin - Babelsberg Observatory, where he remained for 25 years.

His scientific work was confined chiefly to the bibliographies and catalogues of stars. His first astronomical paper was a dissertation on the seventh satellite of Saturn which he dedicated to his mother. A colossal work on positional astronomy was published by him in 1924. This contained 8,803 stars whose positions were determined by Dr. Prager with Bottlinger's co-operation during the years 1918-1923. Another catalogue of 1,885 stars followed.

In 1925, he began the work which later made him famous, a yearly catalogue and ephemerides of variable stars; he was aided by Guthnick and Heise, but from 1926 to 1936 he carried on this work alone. At the same time he undertook another stupendous work concerning the history of variable stars. In 1934 he published the first volume of this history; in 1936, the second volume.

His plan was to finish the history in three volumes and to publish a supplement, as well. On account of the political changes in Germany, Dr. Prager was unable to finish the third volume as planned, for he was not allowed to take the manuscript to the United States. But with the encouragement of the director at the Harvard College Observatory, he finished the supplementary volume, containing 3,592 variable stars studied by astronomers in the years 1931-1938.

For six years until 1936, he was secretary of the astronomical society in Germany and editor of the yearly reports on astronomical activities. He published two volumes of suspected variables; a treatise on the nomenclature of variable stars; and a table for light equations. In 1932 he was appointed to the Variable Star Commission of the International Astronomical Union.

In research matters, he worked on the well-known cluster-type variable, RR Lyrae; with Guthnick he studied 45 variable stars photographically and photoelectrically; at Harvard he revived his interest in the changes of period among the cluster-type variables, and was deeply interested in variable star work at this observatory.

Dr. Prager had extensive correspondence with contemporaries all over the world—he enjoyed scientific and social contacts, and especially remembered his pleasant stay in Chile. He had one son in Germany, whom he had hoped would come to America some day.

Keen in his desire to help with the war, Dr. Prager worked for a time at Massachusetts Institute of Technology, but finally his health prevented further effort of this kind.

We may make a closing tribute by quoting the words of Nijland concerning the first volume of the history of variable stars: "Professor Prager is to be congratulated on the completion of the first part of the important and enormous task he has undertaken."

SERGEI GAPOSCHKIN
Harvard College Observatory

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SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $2.50 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.00; all other foreign countries, $3.50. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance. Circulation manager: Betty G. Dodd.

Editorial and general offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we do not guarantee prompt editorial attention under present conditions, nor are we responsible for the return of unsolicited manuscripts unless adequate return postage is provided by the author.

Advertising director: Fred B. Trimm, 19 East 48th Street, New York 17, N. Y.; ELdorado 5-5750.

The first instant of totality as recorded with camera S in the Spitfire at 34,000 feet, the highest photograph of an eclipse ever obtained. The direct image of the sun is at the right, and the first-order spectrum appears to the left of center. In addition to the strong lines of hydrogen, helium, and ionized calcium, many faint chromospheric lines arising from lower levels can be seen. This is the first of a series of 14 similar photographs obtained from the Spitfire during totality.

R.C.A.F. OPERATION "ECLIPSE"

BY SQUADRON LEADER PETER M. MILLMAN*

Operational Research Officer, Royal Canadian Air Force Headquarters, Ottawa

OPERATION "Eclipse" was planned by the Royal Canadian Air Force for the purpose of making photographic observations from the air of the total solar eclipse of July 9, 1945. The program was carried out by No. 7 Photo Reconnaissance Wing of the Air Force, and was co-ordinated with the comprehensive series of ionospheric observations sponsored by the Canadian Radio Wave Propagation Committee.

The base of operations was the Central Navigation School of the R.C.A.F. at Rivers, Man. Four aircraft were employed, a Spitfire, a Mitchell, and two Ansons. In three of these, seven cameras (three spectroscopic and four direct) were mounted, the camera axes being directed out the port sides of the planes at an elevation of approximately 12 degrees. The fourth aircraft, an Anson flying at 15,000 feet, was employed to give motion picture coverage of the partial and total phases.

The spectrographic observations were designed to give a complete photographic record of the chromosphere and corona throughout totality, and in particular to make a study of the polarization in these spectra. The direct cameras were used to record the corona and prominences in the visual region as well as in the infrared. All cameras were standard types employed in aerial photography. They were mounted behind windows of specially selected plate glass.

With the exception of D, the cameras were adjusted to take photographs automatically once they had been started. Cameras A, B, and S made one complete exposure approximately every two seconds; C, X, and Y, one exposure every four seconds. The maximum duration of totality over the section of the eclipse path used in the air observations varied from 33 to 38 seconds. The three aircraft with mounted cameras were kept on the correct heading through a modification of the pilot's reflector gun sight; each sight was installed and

CAMERA DESIGNATIONS AND SPECIFICATIONS

Aircraft	*Camera*	*F.L.*	*Effective aperture*	*Lens*	*Filters, etc.*
Mitchell	A and B	20"	3.6"	Cooke telephoto	Grating by Wood, 14,440 lines/in. Dispersion 33A/mm. Polaroid filter.
	C	36	5.7	Booth telephoto	
	D	8	5.3	Eastman	
Spitfire	S	8	2.8	Dallmeyer Pentac	Grating by Wood, 14,440 lines/in. Dispersion 79A/mm.
Anson	X	36	5.7	Booth telephoto	
	Y	20	3.6	Cooke telephoto	Tri-color A filter No. 25.

The cameras employed in the aerial observations carried out by the R.C.A.F. during the eclipse of the sun, July 9, 1945.

*At present on leave of absence from David Dunlap Observatory, University of Toronto.

so adjusted that if the pilot kept the image of the sun central on the sighting rings, the cameras were pointed to the sun. The procedure was to steady the aircraft on the correct heading a few minutes before the computed time of totality and then carry out a timed run, flying south across the eclipse path. Cameras were turned on a minute before mid-totality and kept running for a minute after.

Exposure times were a compromise. It was desired to make them as long as possible for the purpose of recording faint detail, but too long an exposure would result in poor definition due to vibration and motion of the aircraft. With all cameras but D, 1/40 second with a focal plane shutter was used; with D, a between-the-lens shutter gave an exposure of 1/25 second. Fine grain was sacrificed to speed, and Eastman Aero Tri-X film was used throughout except in Y, which was loaded with a specially fast Eastman infrared film.

During the week prior to the eclipse, a number of test runs were carried out over the eclipse route, test exposures with all cameras being made through neutral density filters with log transmission between minus 6 and minus 7. On eclipse morning it was clear at Rivers before dawn, and all planes took off on schedule shortly before 6 a.m. The route of the Spitfire, piloted by F/L T. M. Percival, lay due north to a landfall at about 52½° N, 100½° W. Fortunately, visibility was good and ground marks could be easily identified. The Spitfire operated at between 33,000 and 34,000 feet, the thermometer going off the bottom of the scale at —60° F. A timed run south from landfall was carried out successfully, and 14 spectrograms, showing both coronal and chromospheric lines, were secured during totality.

The Anson operated at 17,000 feet

The Spitfire aircraft used on operation "Eclipse." From this plane was taken the spectrum reproduced on page 3. Photo by the author.

in the region near 51° N, 102° W. It was piloted by S/L G. E. Cherrington and navigated by S/L J. F. Heard (on leave of absence from David Dunlap Observatory). During totality, 16 direct photographs of the corona were made with cameras X and Y.

The Mitchell was piloted by S/L J. A. Wiseman, AFC, with the writer as navigator. On the flight northwest a stratocumulus layer was encountered between 7,000 and 9,000 feet, and all sight of the ground was lost 10 minutes after leaving base. It was decided then to use radio navigation and carry out a timed run from radio station CJGX at Yorkton. We entered a thin haze layer at 26,000 feet and were still in it at 28,000. Top of haze seemed to be above 30,000 feet, so it was necessary to come down to 26,000 again which complicated the navigation appreciably, since the final run had been computed for slow speed in climbing altitude. With a strong tail wind, the actual run across the path of totality was made at a ground speed of about 250 miles an hour. Temperature was near —40° F., and a bit of frost appeared on the window of the nose camera, but was cleared with alcohol. The twin spectrographs and one direct camera were in the rear and their windows were perfectly clear. In the Mitchell, 21 spectrograms and 13 direct photos were obtained with the four cameras (the shutter in A failed on one exposure during totality).

As all crew members were fully occupied with the operation of cameras and aircraft, no detailed visual observations were made.

It is too early yet to report on the scientific results. The spectra will be studied photometrically. Hasty

(Continued on page 15)

A direct photograph near mid-totality with camera X in the Anson at 17,000 feet. Heavy printing brings out the prominences which were visible at the time of totality.

Amateur Astronomers

THIS MONTH'S LECTURES

Chicago: On Tuesday, September 11th, at 8:00 p.m., the Burnham Astronomical Society will hear a short discussion of the September evening sky by C. L. Baker, to be followed by the feature lecture. Dr. O. J. Lee, of Dearborn Observatory, will lecture on "Seeing the Universe," and show an astronomical motion picture. The group meets at the Chicago Academy of Sciences Auditorium.

Cincinnati: "The Constellations" is the subject of an illustrated lecture by Daniel E. McCarthy, secretary-treasurer of the society, before the Cincinnati Astronomical Association on Friday, September 14th at 8 o'clock. The lecture will be at the Walnut Hills Branch Library, Kemper Lane and William Howard Taft Road, and not at the usual meeting place at the Cincinnati Observatory.

Detroit: Members and guests at the opening fall meeting of the Detroit Astronomical Society, on Sunday, September 16th at 3 p.m., at Wayne University, will attend a "Wolseley Reunion," with a number of the eclipse observers participating in the discussion of results of the expedition. An informal dinner in honor of the guest speakers is scheduled for the close of the meeting.

Indianapolis: A "Sky Symposium," including discussion of the Milky Way, will be held at the September meeting of the Indiana Astronomical Society, on Sunday the 2nd, in Odeon Hall at 2:15 p.m.

N. Y. ANNUAL WEEKEND

For the seventh time, the Amateur Astronomers Association is conducting its annual weekend excursion to Blue Mountain Reservation near Peekskill, N. Y. Headquarters for a limited number of members over the Labor Day weekend, September 1-3, will be the beautiful Trail Lodge, with its fine accommodations and facilities for all kinds of outdoor and observing activities. At night, constellation study will be carried on without interference from the moon, but the notice to the members states that the trip is on—rain or shine!

In the Moon's Shadow

These excerpts are taken from more than a dozen comprehensive reports received. Space permits use of only a few of the fine pictures of the eclipse and of amateurs and their equipment.

SUNRISE ECLIPSE. I flew up from Los Angeles to Butte on July 8th. Going by plane I couldn't take much equipment. However, I did have a pair of Zeiss 12x40 binoculars and an Argus camera. There is a high range of mountains to the east of the town, which the newspapers said would make the total eclipse invisible in the city.

Very early the morning of July 9th a cab brought me to the bottom of Big Butte, a hill after which the town was named. I hiked to the top, and was up there around 5:30. By six o'clock quite a crowd had gathered atop the butte. Just then some dark clouds appeared on the eastern horizon but they gradually broke up. Totality was scheduled to begin at 6:13.51 M.W.T. and at 6:10 the sun had not yet risen, and I had almost given up hope of the sun rising in time. There was a mountain peak in the way, or doubtless the sun would have risen quite some time before this.

At almost precisely 6:12 a thin, crescent sun appeared over the mountain peak. The planet Venus, which had disappeared with the dawn, reappeared and swiftly increased in brilliance. For an instant a weird greenish glow seemed to be prevalent on the earth. Shadow bands moved swiftly across the ground. All was silent. Then the characteristic red band, the chromosphere, appeared on the edge of the sun. I tried to get a picture of it but it was too quick. Then the gloriously beautiful corona appeared, light orange in hue and very spectacular. The corona was visible for a short 25 seconds; it hardly seemed to me even half that long, but I got a beautiful view of it through my binoculars.

The appearance of Baily's beads and the chromosphere signaled an end of totality. This was my first total eclipse, and despite its short duration, it was one of spectacular grandeur. It was well worth the trip, and will live long in my memory as one of the most glorious spectacles I have ever observed.

WARREN HOLLISTER
Los Angeles, Cal.

AT MALTA. The total solar eclipse took place during 11 minutes of clear sky which enabled us to make our observations while the sun was passing from behind one cloud bank to another.

On account of the clouds, stars could not be seen during totality. Color effects were most impressive and of a kind never duplicated at ordinary sunrises or sunsets. During the eclipse, the sun was only 7° above the northeastern horizon, and underneath it could be seen a saffron glow from sunlit air beyond the boundary of the moon's shadow.

The phenomenon of the "falling shadow," characteristic of a sunrise eclipse and not previously described, was satisfactorily observed. Seven pairs of local volunteers, one of each pair acting as ammeter reader and another as recorder, measured the brightness of the sky in four horizontal directions and overhead by means of photocells. These measurements, when studied, will yield useful information concerning the passage of the moon's shadow, and the darkness during totality.

JOHN Q. STEWART
Princeton University Observatory
and JAMES STOKLEY
General Electric Co.
Schenectady, N. Y.

SUN WATCHERS. Of the many local residents of Malta who engaged actively in eclipse observations, 14, known as the Sun Watchers, volunteered for special concentration on the sun's corona.

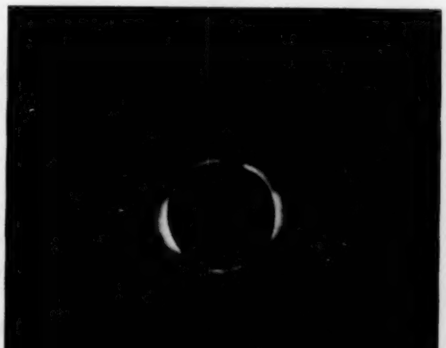
The consensus of their observations and opinions is to the effect that, as mentioned in the Malta report last month, the coronal streamers appear as searchlights projected through a hazy and luminous disk of fog, instead of being visible as distinct radiations against a dark background of sky or space.

Impressions and observations were recorded upon conveniently marked form cards immediately following totality. As directed by Dr. Stewart, instruction and coaching in this phase of the observations had been conducted at the City Hall under my guidance. My original intention was to go to Saco, but at the request of Dr. Stewart and Mr. Stokley, I remained in Malta and took over this part of the work.

Three outstanding features of the eclipse were the unusual darkness at totality, the complete absence of beads as seen from our station, and the fortunate rift in the clouds which presented a clear sky, not over four sun diameters in width, between 6:07 and 6:18.

The people of Malta left nothing undone in the way of co-operation and friendliness, and the interest of those who took part and aided in the observations was keen and devoted.

LEWIS LINDSAY
San Francisco, Cal.



The inner corona at Saco, photographed by the Montana State University expedition, using a Leica and 155-mm. telephoto lens; the picture is an enlargement.

MONTANA STATE UNIVERSITY. Our eclipse party observed from a position half a mile north of the center of totality and 1½ miles south of Saco, Mont. It consisted of six members led by Dr. H. Chatland, of the department of mathematics. We hoped to secure photographs of the partial and total phases, of the flash spectrum, of the moon's shadow in the western sky, and of the horizon glow.

The sun rose at 5:18 M.W.T. into a broken sky. At an altitude of four degrees it went behind a cumulus cloud bank and did not emerge completely until two minutes before totality.

As the moment of second contact approached, the landscape colors began to redden slightly, then washed out and took on a gray hue. The crescent sun had a reddish tint.

An instant before totality, Baily's beads suddenly flashed out completely around the moon, being very brilliant near seven o'clock and small near two o'clock, and outlining the entire disk of the moon which was a very light blue. Before anybody in the party could react and take a picture, the beads disappeared and the corona

flashed out. Everyone was so busy during the brief period of totality that no detailed observation was made of the corona. It was elongated at the equator and brightest at three o'clock.

The sky was black or bluish black from the east through the zenith to the west. The horizon glow in the south-southeast was unobscured by clouds, the colors ranging from dark blue at 60° altitude to light blue at 20°, reddish at 15°, and a dusty yellowish red on the horizon. In the north, a cloud bank extended from an altitude of 5° to 15°. Below this bank the sky had a dusty red appearance; above, it was blue. The general illumination was much greater than that of a full moon, a Secron stop clock being easily read throughout the total phase. As the timekeeper counted out the 29th second, a Baily's bead flashed out at two o'clock and the total phase was at an end. The moon's shadow could be seen on the eastern horizon for about a minute.

Kodachrome exposures were taken with a short-focus, wide-angle lens, of the corona and the horizon glow, but the results are not yet known. No pictures were possible of the pretotality shadow due to clouds in the west.

BERNARD HOFFMAN
Missoula, Mont.

CALIFORNIA GROUP. We have recently returned from a flight into northeastern Montana, where we viewed and photographed the total solar eclipse of July 9th.

The expedition was made in conjunction with the Frank P. Brackett Observatory of Pomona College and with the kind assistance of the staff of Mount Wilson, who lent instruments and provided film, as well as giving valuable advice. The astronomy department of Pomona College was represented by the director of the Brackett Observatory, Dr. Walter T. Whitney, his daughter and young son, and two Pomona astronomy students. Dr. Sprague, of Wheaton College, also accompanied this group.

The motion picture setup at Opheim. The heliostat clock was driven by the weight suspended from the tripod.

The Pomona group drove to the eclipse site in Opheim, Mont., from southern California, taking the greater part of the equipment in a trailer, arriving on the 4th of July. Our contingent of two from the Mono Observatory flew up from Minden, Nev., arriving in Glasgow, Mont., at the Army Air Field on the 7th. We were transported to Opheim by government car provided through the courtesy of Jack Messmer, facility supervisor at the field.

The equipment, set up on the roof of the local high school, consisted of the two coronal cameras and three motion picture cameras mentioned in last month's account. The motion picture cameras were a 16-mm. Cine Kodak and a 35-mm. Bell and Howell, operated continuously during the eclipse, and a 35-mm. Sept, operated only during totality. All three were fed by a 12-inch portable field heliostat. The two 35-mm. cameras photographed images provided by achromatic lenses of 29.5 inches focus and the 16-mm. an image of 12-inch focus. The 3-inch clear aperture lens used with the Sept was left open to allow all the weak coronal light to enter. This instrument was manually operated during totality, using several different exposure times, from one to 10 seconds in duration. The other motion picture units were operated automatically, one frame every six seconds, by a switch on the heliostat driving clock, which controlled solenoids energized by storage batteries. The solenoids, in turn, tripped the camera shutters. The whole arrangement was firmly mounted on a prefabricated stand.

The coronal cameras, of 14 and five feet focus, were fed by 6-inch heliostats with alarm-clock drives, and fitted with 5x7 plateholders. Plates with special emulsions were furnished by Mount Wilson. A strip about an inch wide at the top of each plate was left unexposed, for photometry.

From the time of our arrival the weather was in doubt. But by Sunday evening we were encouraged, as the wind died and the afternoon clouds dissipated, revealing a starry sky. Last-minute checks were completed about 9:30 p.m., when it was discovered that the mainspring in one of the alarm-clock heliostats had literally exploded, bursting its metal case with the pressure. We set quickly to work to make repairs, and these were just about completed at midnight when a loud bang announced that something in the other clock heliostat had given way. Investigation revealed a broken mainspring and hairspring. We were not prepared for this double calamity, but we soon routed out the town jeweler, who completed repairs by 3:00 a.m.

We arose at 3:30 after you-can-imagine-how-much sleep, and saw in the eastern sky a most unwelcome bank of altostratus and cirrus, which grew steadily heavier until the red glow announced the sunrise. The solar disk, only partially visible, rose into the cloud bank and disappeared. We had hardly time to set the heliostat mirrors by its weak illumination before it was lost completely. The instruments were put into operation according to planned procedure. All was silent on the roof except for the click of the automatic cameras.

Shortly after sunrise we discovered that the film in the Bell and Howell had jammed, and it was demounted and adjustments made. No hurry—nothing to photograph.

The instruments clicked on, and the time for totality approached. As its altitude neared the 9° of totality, the sun slowly crept out into the clear.

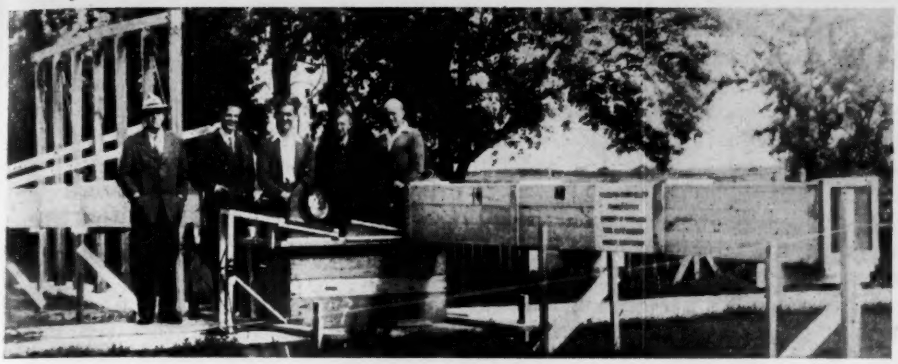
Quickly we adjusted the corona camera heliostats; more quickly we put in the plateholders, and all operators stood ready for the big moment. We were to make exposures beginning with the disappearance of Baily's beads, one second for the first, 15 seconds for the second, and as many seconds as remained until the beads again for the third.

With unbelievable rapidity the crescent closed. For a split second the beads appeared. Darkness descended. The count began. We made our first exposure, not without some fumbling. The second exposure begun, we glanced up for our 10-second look at the eclipse.

After the eclipse was over, we walked to the nearby village church for a community breakfast, where we heard related the old stories of the chickens going to roost, and one which didn't quite make it was said to have lain down halfway to the roost.

We carried our films and plates to the plane and took off for home, 1,200 miles distant. Our negatives are in the laboratories of the Mount Wilson Observatory. The rest of the story waits for what they will reveal.

ALBERT V. SHATZEL
and WALTER M. LORENZ
Mono Observatory, Coleville, Cal.



The long coronal cameras of the Philadelphia expedition set up at Wolseley, with the 18-foot camera in the foreground, and the 40-foot in the background. Both were fed from the heliostat and coelostat on the pier in front of the men. Left to right in the photo are Thomas Tiller, Wolseley town clerk, Stanley Cole, mayor, Dr. Marshall, Dr. Mohler, and Dr. Sutton.

EXPEDITION TO WOLSELEY. The Philadelphia *Evening Bulletin*—Franklin Institute — University of Pennsylvania eclipse expedition to Wolseley, Sask., photographed the corona in a clear sky. One camera, of 5-inch aperture and 40 feet focal length, failed to function; with it, short exposures to show the prominences and inner corona were planned. The 6½-inch camera of 18 feet focal length functioned well, but pinholes in the emulsion produced a number of small, round, black dots on the print. With a pair of 4-inch Ross lenses of 28-inch focal length, pictures were taken for full duration, with filters and plates that passed particularly well the red and green lines of the coronal spectrum.

By working from 4 p.m. Friday until midnight Sunday, we installed the instruments. A large packing case on a concrete sidewalk was tied down by stakes, to form a pier for the heliostat feeding the 40-foot camera and a coelostat feeding the 18-foot. Wooden tubes were constructed for the barrels of the cameras. Another packing case served as the pier for the mounting carrying the twin 4-inch cameras. All three polar axes were raised to the proper latitude by means of wooden wedges prepared in Philadelphia. Focus plates on the Ross lenses were made by Dr. Orren C. Mohler; the long cameras were focused visually, inasmuch as the plates were sensitive to visible light.

The plates made with the Ross lenses show far greater extent of the corona than does the one full-duration photograph taken with the 18-foot camera. Particularly, an almost parallel-sided bar of corona, about one solar diameter in width, extends for more than two solar diameters to both east and west of the sun's limb.

The scientific members of the expedition were Dr. Mohler, astronomer at the McMath-Hulbert Observatory, Dr. Richard M. Sutton, professor of physics at Haverford College, and the writer. Dr. Sutton operated the Ross cameras; Dr. Mohler was assisted by Douglas Green, of the Canadian Press, at the 40-foot; and I was assisted by Janet Anderson, of Detroit, Mich., at the 18-foot. Immediately after development of the plate made with this camera, the wet plate was rushed by train into Regina, where it was printed and transmitted by Associated Press wirephoto over country-wide news wires.

One feature of the expedition's activities during the eclipse was a broadcast by direct wire to Philadelphia and Washington; the broadcast began 11 minutes before totality and lasted until nine minutes after it.

The work and comfort of the members of the expedition were considerably aided by the kindness of many local citizens, chief among whom were Mayor and Mrs. Stanley Cole, and Town Clerk and Mrs. Thomas Tiller. F.W.C. Jones, of Trenton, Mich., had arrived a few days earlier and had done good work in starting the conversion of the school library into a darkroom. For the facilities of the school building, in front of which the instruments were set up, the expedition is especially grateful.

Roy K. Marshall
Fels Planetarium

TEXAS OBSERVERS. Our party, consisting of Robert G. Brown, Mr. and Mrs. Otto W. Monnig, and Mr. and Mrs. Oscar E. Monnig, all of Ft. Worth, Tex., successfully saw the eclipse from just east of Wolseley. At first we were at a point six miles east and a little over one mile north of the eastern limit of the town.

A few low streaks of cirrostratus in the northeast threatened us from sunrise on. I wondered if the presence of the Qu'Appelle valley had anything to do with their formation and persistence. At any rate, I thought they were tending to drift southwards and gain a little in altitude, and as totality approached we feared the sun might not completely clear the clouds. To make sure, our personal party of five moved back to five miles due east of Wolseley. We made this running move at 5:55 a.m., only some 16 minutes before totality!

A sheet was laid out on the section road, and at about 6:14 Brown thought he noticed the wind rippling it slightly, but less than a minute later, several of us saw and identified the appearance as shadow bands. They were straight (not wavy or sinuous), definite, and at regular intervals, and clearly moved directly *south*, down the section road. The dark portions of the bands were probably near ½ or ¼ of an inch wide, and these were separated by four- to six-inch intervals. Brown felt the dark bands were not sharp, but faded off at the edges and were more intense at the center, which would account for the difficulty of estimating their width. They did not appear steadily, especially at first, but came in groups or installments of perhaps five or 10 seconds' duration. Speed estimates varied from six to eight feet per second (early ones; Brown) to perhaps two feet a second (later ones before totality; Monnig).

After totality the bands were again seen by all of us till 6:20 or a little later. They were positively moving the same way (south), and none of us thought they differed in any descriptive way from the pre-totality bands.

The approaching upper-air shadow, as a large rectangular to ellipsoidal bluish block of air somewhat south of west, was plainly seen just before totality. The beads and the dazzling diamond ring effect, both at the beginning and end of totality, were magnificent.

Saturn and the corona seemed to appear simultaneously. The equatorial streamers were well over ½° long, and an especially marked and curved one on the lower left impressed me most. I took a 3-second exposure with my 3.5, 7-inch focal length, lens on Super XX film, the only photo I tried. I looked at the corona and the sun for perhaps 10 or 15 seconds during mid-totality with 8x binoculars.

The mild cold front which had come in 24 hours before the eclipse had cleared the air and the transparency was excellent. There was no reddening of the distant horizon in any direction—at most a faint yel-

lowing like that not uncommon at any sunrise. The general sky coloration was a steel-gray in Brown's words, though I would place more emphasis on blueness, and my brother was inclined to see some greenish tinge. Just as the beads broke again, the receding upper-air shadow was clearly seen, similar to the approach.

During totality, Brown operated a camera specially made by Geary Kimball, of Portland, Ore., and brought by Mr. Richards, of Salem, Ore. He also ran an 8-mm. black-and-white movie camera from just before totality to afterwards—it runs about one minute on a winding—using a 76-mm. telephoto lens, f/4.5 at $1/30^s$. We hope for beads and the diamond ring effect at least.

Oscar E. Monnig
Ft. Worth, Tex.

WOLSELEY FLASH SPECTRA. Portland, Me., and Portland, Ore., had observers in this prairie town. . . .

Slacks and party dresses, sweaters and sport shirts, flowered organdie and trench coats, all were seen at Mayor and Mrs. Coles' reception Sunday afternoon in a delightful interlude from the busy preparation for the world's greatest thrill. . . .

The evening gabfest in the Wolseley hotel, with a large native participation, was a session that would have delighted Copernicus or Galileo. . . .

The eclipse — perfect in a multi-pastel colored morning sky. The beads, the diamond ring, an extended corona on a flawless backdrop; awed groups of natives and visitors, a lone observer on a railroad boxcar; the shadow driving down a Saskatchewan prairie—all is a memory that will linger long. . . .

Then the tremendous letdown. Hurried packing, brief farewells with friends newly made. The transcontinental flier flagged for the departure. And the long trek home. . . .

J. F. Hawk
Petrolia, Pa.

SHADOW BANDS. Northeast of the Wolseley school building a white cotton sheet about eight by six feet was laid on level bare ground, the long side in the north and south direction. The sides were anchored by boards and stones.

Immediately after seeing the brilliant diamond ring effect at the end of totality, two of the party ran over to the sheet. Then several others joined them; about 10 seconds later the writer got there. Over a dozen persons saw the shadow bands on this sheet.

All agreed that the bands were moving sideways from north to south. The speed may have been between six and 10 feet a second. The dark bands seemed to be one or two inches wide. Some observers agreed that the light bands were equal in width to the dark ones, while others thought the light bands were eight to 12 inches wide. The movement of the bands made them seem to be floating above the sheet.

The observers agreed that the intensity of the dark bands varied in cycles possibly two to four seconds long, from faintly dark to distinctly dark, giving a wavy effect. The bands continued to move across the sheet for at least 30 seconds after totality.

Cyril Hallam
Windsor, Ont.

FROM DETROIT. "Camp Cheerio" was a group of amateurs from Michigan who went to Wolseley, Sask., to see the eclipse of July 9th. Joseph Mazer, president, Margaret Back, secretary, and the writers, 15-year-old "satellite members" of the Detroit Astronomical Society, made up the group. The party left Detroit on July 1st and arrived in hospitable Wolseley on the 3rd. By Friday, there were about 22 astronomically minded people there from all parts of the country.

Friday evening, an interested group gathered at the school where Dr. Marshall was beginning to assemble the instruments to photograph the eclipse. For both the 40-foot and 18-foot cameras, there still had to be built wooden tubes to shut out the light and to carry the plateholders. The instruments were all run by electricity wired from the schoolhouse.

Janet Anderson was assigned to help with Dr. Marshall's expedition, and Joanne was going about 7½ miles east of Wolseley, to observe with Fred Falk, of Portland, Ore., and the Davis family from Des Moines. Mr. Mazer, with T. P. Maher, of Portland, Ore., observed at a site about three miles from Camp Cheerio.

Both of us were up most of the night before the eclipse, as were many of the other observers. A weather report during the night from Regina, saying that it would be clear, caused those of us who knew about it to relax considerably. The night was cold, but the sky was sparkling, and there was a glowing display of the northern lights.

After our alarm at the early-morning clouds on the northeastern horizon, the rest of the eclipse was all that could be hoped for. We wore red adaptation goggles while the eclipse was partial, so we could see more of the corona when it burst out, our eyes being accustomed to the darkness. We both thought that the sky remained surprisingly bright during totality.

The rest of the day passed in packing up, a trip to Regina for Janet, and some sleep for others of us. We were to leave on Tuesday morning. As we settled into the train, we smiled at each other. We were wonderfully happy, for we had seen an eclipse of the sun and nothing had gone wrong, and so we rode home in triumph.

Janet Anderson
and Joanne Anderson
Detroit Astronomical Society

PHOTOGRAPHERS. Two of us, Robert A. Woodson, of the Bell and Howell Co., Chicago, and myself, made an informal trip of our own to the region of totality, and located at Wolseley, above the west shore of a small pond on the east side of town. We arrived by train the evening before the eclipse, set up our equipment, and made some photographs of the sunset as an experiment.

Equipment consisted of a Cine-Kodak Special with 6-inch f/4.5 telephoto lens and 16-mm. Kodachrome film; a Speed Graphic with 23¼-inch f/12.5 lens and Kodachrome cut sheet film; two Bell and Howell movie cameras using 16-mm. black-and-white film, to one of which was at-

At Mayor and Mrs. Coles' reception at Wolseley, amateurs from far and wide were gathered. Photo by Carl P. Richards.

tached a 6-inch telephoto lens, and to the other an 18-inch telescope objective; and an Argus miniature camera with Kodachrome film.

The entire eclipse, from first to fourth contact, was photographed. Both manual and mechanical means of time lapse were employed in making a movie record of the partial phases, while during the period of totality the cameras were operated at the normal projection speed.

Venus, Saturn, and Capella were detected at the time of totality, while Venus was, of course, visible throughout the morning. Other stars besides Capella might possibly have been observed had I not been concentrating on the photographic program during the brief interval. PAUL STEVENS

Eastman Kodak Co.
Rochester, N. Y.

FROM OREGON. No arrangements for getting out to the central line had been made prior to my arrival in Regina by train, but on Friday morning, after conference with my friend, J. McD. Patton, of that city, it was decided that Wolseley would be the best location, and we therefore drove out that afternoon. Arriving at the Leland Hotel, we found several of the eclipse delegation already there, and two of my fellow members of the Astronomy Study Group of Portland, Ore., were busy preparing equipment. After checking various locations, we decided to go to a point about six miles east and one mile north of the town. This was about 200 feet south of where Mr. Falk was setting up.

Back in Regina that evening, more eclipse travelers were encountered in the Saskatchewan Hotel, the party which had just arrived from Ft. Worth. They kindly agreed to assist me in carrying out my photographic plans, which were to make an exposure every five minutes throughout the two hours' duration of the eclipse with a No. 120 Kodak; to make two exposures during totality with a 620 Kodak; to make three exposures during totality on 35-mm. color film using a camera especially adapted with an 8¼-inch lens of f/3.8 aperture.

Saturday evening Herbert Haven, of the Portland, Me., Astronomical Society, arrived at the Saskatchewan Hotel, and through inquiries of the clerk, was referred to me. We arranged to drive together to Wolseley Sunday afternoon. An unpropitious thunderstorm delayed our departure from Regina, so we arrived in Wolse-

(*Continued on page* 21)

NEWS NOTES

By Dorrit Hoffleit

STELLAR ROTATION

"The Cosmogonical Significance of Stellar Rotation," by Otto Struve, in two recent numbers of *Popular Astronomy*, is an admirable account of the present state of knowledge on rotation of the stars. As recently as 1931, E. A. Milne cast doubt on the method of determination of rotation from an analysis of spectral line contours by saying: "The principle seems to be that anything that is not understood in the way of contour distortion is attributed to rotation." Much has been accomplished since then. Struve lists seven points considered in arriving at the conclusion that the observed widening of lines in certain classes of spectra logically leaves no room for any other interpretation.

Measured values of the rotational velocities at the equatorial surfaces of stars range from 0 to 250 kilometers per second, while there are indications that a few stars, with lines too diffuse for measurement, may turn at 300 or 400 or even more kilometers per second. The largest velocities are found among the earliest spectral types, *O, B,* and *A;* smaller average velocities are observed among the *F* stars, while for types *G* and later, rapid rotations occur only in close binary stars.

Among early-type stars showing emission, these bright lines indicate roughly half the rotation obtained from the absorption lines. This is consistent with the theory that the shells in which the emission lines arise have radii of the order of twice the radius of the stellar photosphere —observations relevant to the theory of rotational instability.

Rotational instability arises when the outward acceleration at the surface of a star caused by centrifugal forces is greater than the inward gravitational attraction. The maximum observed stellar rotations are presumably close to the critical break-up values. This seems supported by the fact that stars with gaseous shells belong to the most rapidly rotating group. Moreover, the shells appear concentrated in equatorial rings.

In the Pleiades, the rotations of *B* stars are excessively large as compared with such stars in general. An explanation of this is sought in the presence of the nebulosity of the Pleiades. The excessive rotations could be explained provided the entire cluster as such is in rotation, but for this there is as yet no evidence.

In conclusion, Dr. Struve summarizes: "We have given convincing evidence of the existence of large rotations in early-type stars. . . . In the Pleiades the rotations of the *B* stars are excessively large, but in all stars equatorial break-up sets an upper limit to the rotational velocity. We have made it appear probable that the formation of a shell represents the process of rotational break-up, and we are thus probably witnessing by means of our spectrographs the actual formation of the rings of Laplace. . . ."

NOVAE DISTRIBUTION

In recent years, the luminosities of new stars have been established with considerable accuracy, and our knowledge of the absorption of light in space has improved so much that Dr. Dean B. McLaughlin, of the University of Michigan Observatory, has made a study of the space distribution for some 100 novae for which reasonably good data are available.

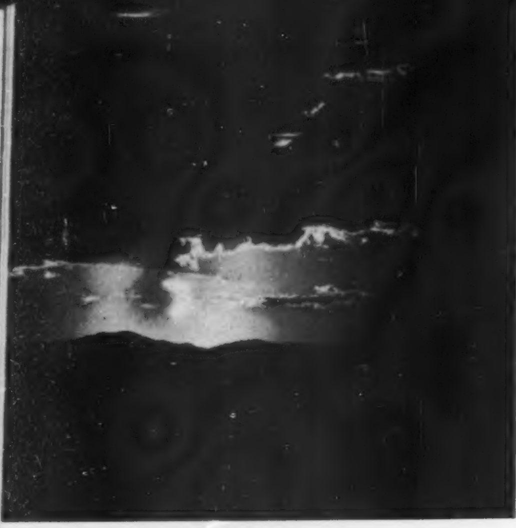
As expected from the general trend in novae discoveries, the new stars usually appear close to the Milky Way, very few farther than 10 degrees from the galactic equator. The densest concentration is in the star-rich Sagittarius region.

The space co-ordinates of these novae locate most of them within 3,000 parsecs of the sun and within about 500 parsecs of the galactic plane. This preponderance within three kiloparsecs is probably due to limitations on the discovery of more distant new stars. The Aquila group of novae appears to be at about one or two kiloparsecs.

Allowable adjustments in the apparent magnitudes of the novae at maximum brightness, and adjustments in the adopted value of space absorption would indicate that the Sagittarius novae are at the distance of the star cloud in that region of the sky. The novae are, however, too nearby to be considered within the nucleus of the Milky Way system, although they may lie in the great bulge of the galaxy that represents the faint outer portions of the true nucleus.

"The present investigation," states Dr. McLaughlin in the *Astronomical Journal*, where the results of his study are published, "gives no definite answer to the question whether the brightest star clouds in Sagittarius are truly parts of the central nucleus of the galaxy."

Outward from the Central Line



The partially eclipsed sun in a cloudy sky, photographed at Ogden, Utah, by M. S. Benedict. An 18-inch lens was used, with Super Panchro Press Type B film, ½-second exposure at f/16, and a green filter.

McPherson, Kan. Breakfast before sunrise was the way the day began for L. E. Hockett, who observed the 75 per cent eclipse with about a dozen friends. He reports that as the moon covered the northern area of the sun the sky to the north was darkened, but the sky directly to the south was of its usual brightness. The best among several telescopes he had were two 15-power achromatic hand telescopes, equipped with sun filters.

Midland, Mich. Crescent images of the partially eclipsed sun were projected through trees and seen on her garage walls by Eva Belle Phillips. She and a friend of hers took notes on the weather, times of immersion and emersion, and the progress of the eclipse.

Chicago, Ill. Observing on the lake front, Robert J. Maulfair and a friend made intermittent drawings and photos of the sun through broken clouds, using a 15x telescope for visual observations at the time each photo was made.

New York State. While on his vacation in the Adirondack Mountains, Charles E. Scovil, of Montclair, N. J., observed a 65 per cent eclipse with his 5-inch Brashear refractor, but he was troubled by poor definition through his sun filter, and some cloudiness. Last contact he timed at 9:11:40 a.m. E.W.T., his location being 74° 17'.4 W., 43° 44'.8 N.

In Utica, Sterling E. Hoffman, Jr., is mystified by apparent changes in color. Wherever sunlight struck he noticed at first a reddish color, then faint blue, then yellowish, after which it returned to normal just as the eclipse was over. He does not mention clouds, but was observing from his room and these effects may have been produced by window-glass refraction.

At Camp Manhattan, Boy Scouts of America, at Ten Mile River, Sullivan County, N. Y., an eclipse expedition was organized with eight scouts participating. One of these, Apollo Taleporos, writes:

"In a camp of 550 boys the eight participants were chosen for their knowledge of astronomy as well as for ability in scientific observation. Their ages range from 16 to 20; two are members of the Junior Astronomy Club and one of the A.A.A. of New York City. At 6:30 we took our stations in a large retreat field, the weather being fairly clear, with some cirrus and cumulus, wind east #2 Beaufort scale.

"Our equipment included three thermometers, a dimestore alcohol, a Wekseler N.Y.C. alcohol, a Dr. Forbes specification mercurial; two sweep-second-hand watches; two three-power French opera glasses; a camera and a visual photometer.

"Immersion (first contact) was timed at 7:07:45 a.m. with both watches; emersion at 9:04:55 with the Mido watch, and 9:04:41 with the Delta. Several pencil sketches were made and six pictures taken at various intervals. Nothing unusual was recorded although we were on the alert for anything. A naked-eye observation (without protective film or smoked glasses) would have given no hint that an eclipse occurred."

Along with this report is a list of photometer readings of the variation of light intensity at five-minute intervals during the eclipse, and simultaneous readings on the three thermometers. The temperature appears to have fallen a few degrees during the early partial phases, and to have risen abruptly right after mid-eclipse.

Worcester, Mass. Norman S. Humes took a series of fine photographs of the partial eclipse through momentary holes in the overcast. He used a 6-inch reflector stopped down to three inches, and had made a wooden support to fit over the eyepiece, which held the camera, a Zeiss Ikon with f/4.5 lens. He used a shutter speed of 1/200.

Seymour, Conn. Clearing skies favored observations made by Miss Eliza M. Chatfield of this community. She was surprised "to see the eclipse start from the top of the sun and move steadily around to the left or north side of the sun and pass away almost at the bottom or opposite from where it had started." The fact that the ecliptic was then making a large angle with the horizon accounts in part for this effect; the remainder is explained by the positions of sun and moon with respect to the node.

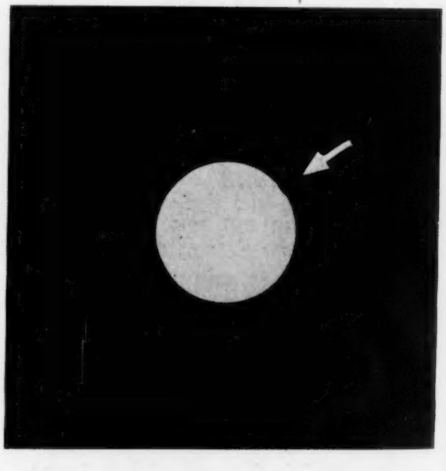
Baltimore, Md. To the naked eye, there was scarcely any noticeable falling off of light at maximum eclipse in Baltimore, where the maximum phase was 56 per cent. James C. Bartlett, Jr., reports also that sky and ground colors remained normal. Telescopically, the sun's low altitude produced considerable boiling of the solar limb and the outline of the moon was distorted. Mr. Bartlett writes:

"At first contact, 7:05 a.m. E.W.T., a narrow bright border was seen around the dark limb of the moon, giving the effect of an atmospheric ring similar to that seen around Venus when the latter transits the sun. This was entirely spurious, of course, and simply an effect of contrast, but very striking. It stopped abruptly at the two edges of contact and could not be traced beyond. This phenomenon remained visible until 8:00, but in the last phases of the eclipse the sun was covered by heavy clouds.

"Two new groups of spots gave opportunity of comparing their color with the black body of the moon. Both groups were extremely dark, particularly the easternmost, the umbrae of which appeared by themselves to be quite black. Compared with the moon, they seemed somewhat whiter, a very dark gray. If 10 be taken as the value for the moon's blackness, then the westernmost and smaller group was at least 8, while the limb group was certainly 9. New spots are commonly much darker than when they are declining; also absorption at the solar limb has the effect of darkening the umbrae.

"When seen in apparent contact with the moon's limb, the westernmost group of spots seemed even darker, at least 9. Certainly these spots were not much inferior to the black body of the moon. My observations were made with a 3-inch refractor of 56 inches focal length."

Bahamas. The partial eclipse was visible for half an hour, through dark film, writes the Rev. Stephen J. Donahue, of New York, who is now in Nassau.



At Norwich, N. Y., with excellent weather for photographic purposes, Dr. Henry E. Paul took a number of pictures of the partial eclipse. Very shortly after first contact, about 7:08 E.W.T., the above shot was made with a Contax camera, Zeiss Sonnar lens of 135 mm. focal length, at 1/500 of a second at f/16. A Zeiss Red R-10 and a 20-per-cent transparent neutral density filter were used. The photograph has been enlarged about 15 times.

ASTRONOMICAL ANECDOTES

"ANCIENT AND BEAUTIFUL THINGS"

IN THIS DEPARTMENT in the March, 1942, issue, I gave a story of the telescope made by Henry Fitz, Jr., for Erskine College at Due West Corner, S. C. The information I had at that time came from two sources: a letter from B. L. Harrell, of Gadsden, Ala., enclosing a clipping from a magazine, and a listing of the telescope in Elijah Burritt's *Geography of the Heavens,* toward the back of the book.

In the latter place, the date of the telescope is given as 1849, its size as 5.6 inches aperture, with seven feet focal length; its cost was $1,050. Now comes a fine letter to the editor of *Sky and Telescope,* which has been passed along by him to me. The writer of the letter is Dr. Charles D. Humberd, captain in the Medical Corps, AUS, 4th Service Command, Barnard, Mo. Capt. Humberd in May of this year visited Due West Corner and examined this venerable instrument.

Contrary to my previous information, the telescope was found "atop a southwest corner of the college's oldest building." It has been there since 1892, probably, when the building had its face lifted. "The telescope rests on a brick column four feet square," writes Capt. Humberd, "and nearly a hundred feet tall, free of its surrounding square tower and of the building. This pillar, whose bricks show some crumbling, is capped by a thin triangular slab of native stone which has cracked asunder. The leaky 10-foot mushroom dome is of homemade construction, of short lengths of board, with a tapering and too narrow slide-off shutter."

If any part of the story that appeared in the earlier account is true, we can well believe that, as Capt. Humberd says, "This Fitz telescope has suffered no little from time's ravages, and tinkerers have not been kind to it, so it is now in only a fair state of preservation. But there can be no doubt that it was once a most noble instrument, custom-made and hand-wrought, of substantial construction and exquisite workmanship. The achromatic objective is in a very thick and heavy screwed-on cell; its external surfaces, both front and back, still appear quite surprisingly clear and clean and unmarred. The between-lens surfaces are, however, much discolored and irregularly corroded, even to the point of pitting, so that one is reminded of the molds and other fungi which somehow seem always to creep into the lens systems of medical microscopes in the tropics. The barrel, of glued and brass-bound mahogany lath, is now warping."

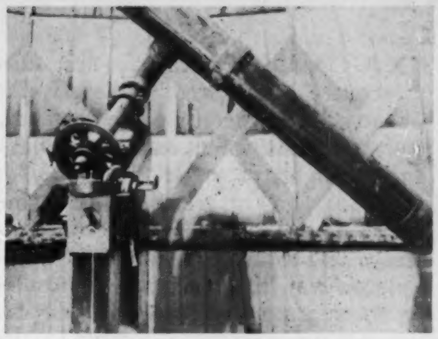
The mounting of the telescope is unmistakably Fitz, a cross between the Fraunhofer and the Secretan type, but much simpler (because of the smaller size) than many of the Fitz mountings with elaborate counterpoise systems to relieve weights at bearing points. The polar and declination axes are each about 18 inches long; the circles are about 10 inches in diameter, rather coarsely divided and intended to be read by two verniers apiece.

"The supporting column," writes Capt. Humberd, "is made up of two 6 x 6 pinned and doweled mahogany posts. The southern one is a typical ship's knee, and the other has two ample braces of similar curve, to give the support a triangular footing. The drive is weight-powered, off the lower end of the polar axis, and it is still in good working order. The gear above its worm shows little if any wear. Simple friction clamps on the circles indicate that all settings were made by hand."

The mushroom dome of the observatory sets high above the structure which is Erskine College's oldest building.

Our correspondent concludes in this vein: "And so this souvenir of a bygone day now reposes in high and soiled and lonely glory. Yet truly it is a most remarkable museum piece —the exhibition hall of some planetarium might look well to the possibilities of its acquisition."

But this is contrary to the story I reported originally, in which the Hon. Robert H. McAdams purchased the lens from a man who intended to use it to replace a broken headlight, and later an amateur of Columbia, S. C., restored the telescope with the original lens and operated it in his private-public observatory. Capt. Humberd substantiates his report with photographs taken in this very year. Will Columbia correspondents please advise?



Details of the mount, the drive, and the wooden tube can be seen here. Photos are by Capt. Humberd.

More than one telescope even now in use for important research "has suffered no little from time's ravages." Why is it that astronomers of just-before-this generation were such poor housekeepers? I know one fine instrument that has yielded much valuable work; it is a very large f/18 photographic telescope east of the Mississippi. A large metal plate formerly covered a hole in the central section of the tube, opposite the point where the central casting is bolted to the declination axis. The metal plate was replaced by one made up of wooden lath glued between circular sheets of oilcloth. One day, as the plate was being removed to gain access to the central casting, one of the strips of wood, perhaps an inch wide, half as thick, and two feet long, fell clattering down the observing ladder to the floor. One of the astronomers—he smokes a pipe and is well known for his dry humor—blinked just a little and grunted, "Hmm, so that's where those things have been coming from!"

R. K. M.

NATURE OF LIGHT AWARDS

Creation of the Charles L. Mayer Nature of Light awards has been announced by the National Science fund of the National Academy of Sciences.

The two prizes of $2,000 each are to be presented in 1946, one for a contribution with respect to our basic understanding of the nature of light and other electromagnetic phenomena; the other to be a comprehensive contribution to a logical, consistent theory of the interaction of charged particles, including those moving with high relative speeds, with an electromagnetic field.

Notes on the Natur[e] [o]f

By Duncan Macdonald, *Boston U[niversity]*

Part II

PHOTOELECTRICITY, first discovered by Hertz in 1889, is the phenomenon whereby all substances emit electrons when under the influence of light, provided the energy of the radiation is greater than some threshold value which varies from substance to substance. This is the principle on which the familiar electronic-type exposure meters, such as the Weston, operate. Light striking the cell surface produces electrons in numbers proportional to the illumination. Experiments have shown that the photoelectrons are still emitted even if the illumination is very weak, so weak that calculations based on the wave theory of light show it to be months before any one atom would absorb enough energy to liberate an electron. Also, the velocity with which the electrons are driven off is in no way connected with the amount of the illumination, weak light giving just as high a velocity to a few electrons as strong light does to many electrons.

And so, in the face of the Michelson-Morley experiment and Hertz' discovery, scientists started again to puzzle out the nature of light.

At the turn of the present century, Max Planck, German physicist, stated his law of radiation, which well fits our observation of colors and temperatures of radiating bodies. Planck made the assumption that radiation is not emitted continuously by the source, but intermittently in bundles of definite energy content. These bundles were called *quanta*. In 1905, Einstein extended Planck's thought by assuming that not only was the source radiating discrete energy bundles, but that these bundles traveled through space in that form, as indivisible energy packets and not as spreading waves. In the case of light transmission, the term quantum was then replaced by the term photon and today we speak of these energy packets of light as *photons*. The energy of a photon equals its frequency times h, Planck's constant; thus, photons of violet light have more energy than photons of green or red light.

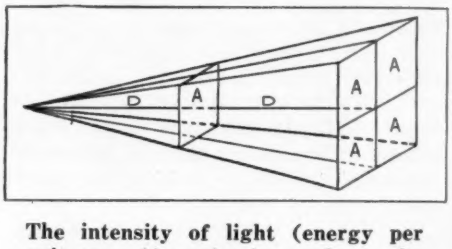
This theory fits all observations. The photoelectric effect, for example, is explained by the fact that when a photon containing enough energy strikes an atom, it drives an electron from the atom. A weaker (less intense) light source is sending fewer photons, hence it liberates fewer electrons. In the case of monochromatic light, having only one frequency, each individual photon has the same energy as the others and each gives the same velocity to every electron liberated.

Now let us consider the fundamental law that governs the microcosmos, the world of atoms and photons: the law of probability. Yes, it is the same law which tells us that a penny has a 50-50 chance of coming up heads, provided, of course, that the coin is not weighted and has only one head.

The atom is made up of a nucleus around which are energy levels or shells, and the electrons exist in these shells, their distribution being in accordance with probability law. An electron cannot be thought of as existing in some part of an orbit, but as practically occupying an entire shell at once. An electron in one shell is characteristic of a certain energy and if it moves to another shell it must change the energy content of the atom. As these changes take place, the electrons jumping from shell to shell obeying the law of being where they most probably should be, the energies involved are balanced by the radiation or absorption of photons. There are various energy levels in any one atom, and the distribution of these levels differs from substance to substance. Many energies can be radiated, and this results in our perception of radiant colors. The sensation of red is produced by photons of less energy than those which produce violet.

The laws, including probability, that govern the actions of the microcosmos have been pieced together in a new mathematical study called quantum mechanics. One of the principles arising in this study is an inherent limitation of nature. It states that it is impossible to determine simultaneously within certain limits both the position and momentum of a particle. This tells us that the more accurately the position of an electron is determined, the greater is the corresponding uncertainty in its momentum (mass times velocity). This *uncertainty principle*, first enunciated by Werner Heisenberg in 1927, turns out to be the only theory that predicts the observed structure of atomic spectra.

Not limited to the physical sciences, uncertainty has been long sought by philosophers. Throughout the ages, it has been impossible to justify freedom of will scientifically. If the atoms of the human body were all in definite positions, it was thought to be possible by Newton's laws to predict the future course of these atoms, that is, they would all be predestined by their initial co-ordinates and moments. Today, with even Mother Nature uncertain as to where these atoms are, the latitude allowed by the uncertainty principle gives room for freedom of the will. The trend of philosophic thought must be away from



The intensity of light (energy per unit area A) varies inversely as the square of the distance (D) from the source.

absolute determinism toward a kind of statistical determinism.

Probability and uncertainty together have explained diffraction of light, and all the other phenomena that seemed justifiable only by wave theory with but one exception, that of polarization.

Before discussing this, I wish to answer a question that often arises. Is there any way to prove that photons obey probability laws? Until recently I should have had to qualify any answer I made, but now it is possible to say yes.

For quite some while men tried to find a case where, by taking very few samples, probability would show some variation. For example, if we toss one penny 10 times, more often than not it will come up heads either 60 per cent or 40 per cent of the time. In other words, although the laws of chance tell us that in 10 trials we shall most likely get five heads and five tails, it is not at all uncommon to get six of one and four of the other, or even seven and three. But in 1,000,000 times, the percentage difference between the total number of heads and tails will always be negligible. In the case of atoms, we are always dealing with such large numbers of them that probability gives an accurate picture.

Light coming from a point source spreads out in all directions, and as the distance from the source increases, the number of photons passing through a unit area in unit time must become less according to the inverse square law. Working at a consider-

re f Light

ton U ity

able distance from a small source would mean dealing with few photons. Unfortunately, even employing this idea, our receivers of light energy had failed to register few enough photons to detect statistical variations similar to those found in the samplings of coin tosses described above.

Recently, however, Selig Hecht, at Columbia University, has performed some precise visual measurements. He tried to determine the minimum number of photons necessary to stimulate vision, using a small portion of the retina of the eye of each of his subjects and performing his experiments under ideal conditions. At the limit of vision, it took about 100 photons striking the cornea of the eye; of these 94 were absorbed in the eye and six, on the average, got through to the retina. Now, here was a case dealing with so few photons that probability should produce variations and it did, in absolute agreement with the probability distribution curves! Sometimes five, sometimes seven photons would get through to the retina. The subjects, by indicating awareness of the light signal, verified the probability distribution. Thus, we have proof that probability, which explains all our observations, is truly the way photons behave.

And now, how can a photon be polarized? As we know it, polarization of this nature could only take place in the case of a transverse wave, where the vibration is at right angles to the direction of propagation, as in the case of a vibrating string. The diagram on page 8 of last month's article gives but an instantaneous picture of the wave train. Electromagnetic energy is emitted discretely, in discrete wave trains. For each such wave train, the space orientation of the H (and E) vectors is different, so that, in the shortest time in which an observation can be made, probability has distributed the H vectors over all orientations. Polarization then occurs when, by some other means, the waves of certain orientations are absorbed or eliminated from the series of wave trains. By convention, the plane containing the H vector (horizontal in the figure) is the plane of polarization.

Certainly light, in spite of its photon nature, possesses some not unlike wave characteristics. Photons seem to be guided through space by probability waves. This might indicate that there is structure of space beyond the limit of our sense comprehensions. Our picture of the physical universe is based primarily on interpretations of the responses of our sense organs. Realizing this, and that we have a limited number of such organs, it does not seem unreasonable to assume that physical phenomena exist which are outside the realm of our awareness. For example, a century ago we did not know that radio waves existed throughout all space. The advent of radio detectors has made us aware of this radiation for which we have no natural receptors. Recently, the strength of radio signals from stars, galactic static, has been employed in studies of the distribution of mass in our galaxy.

Dr. Royal M. Frye, of Boston University, has suggested that photon movement is guided by a multi-dimensional wave and that we are conscious of only a three-dimensional cross section of its effects. Thus we may have the peculiar circumstance of a wave phenomenon producing effects like polarization in the behavior of a particle.

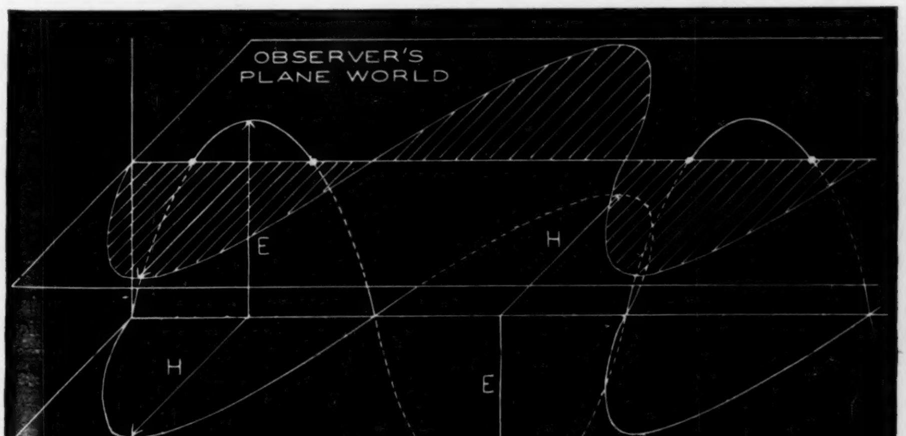
As an analogy, consider the observation that a one-dimensional (single line) being would make of a two-dimensional (plane) wave disturbance. The disturbance would cut into his world at a series of points; they would be the only portions of the disturbance our good friend could detect, for all the rest of the wave would be outside his world. I daresay his interpretation of the wave phenomenon would be that of a corpuscular or photon nature. The energy discernible to him would be concentrated at separate points (photons).

If we expand this idea to a three-dimensional wave and a two-dimensional observer, the wave is our normal concept of the electromagnetic three-dimensional wave, with two disturbances at right angles to each other. For the two-dimensional (plane) observer, the horizontal disturbance exists entirely in his world while the vertical disturbance cuts his world at discrete points. Thus, this observer is aware of a wave and corpuscular disturbance. And so, in Dr. Frye's suggestion, we, as observers in a three-dimensional world, detecting a four-dimensional wave cutting our three dimensions, may expect to observe a three-dimensional disturbance and an associated disturbance of photon nature.

Does it bother you that we have based our universe on no more definite a rule than probability, that we find electrons are fuzzy energy concentrations, and we don't know exactly where they are? I think we can see why this is so. Frankly, we are using probability to cover a multitude of complexities that we can explain in no other way. As Eddington has said, it takes 10^{27} atoms to make a man and 10^{28} men to make a star. Man is almost the geometric mean. As science developed, it was natural that we should first find out laws about objects near our own size. We have done this, and the Newtonian mechanics involved is familiar to all high school physics students. As science grows up, it is just as natural to probe farther and farther away from our central location — to the atoms and the galaxies — and as we go the way becomes less familiar. Science is merely developing growing pains.

The laws of objects near our own

(*Continued on page* 15)



To a two-dimensional (plane world) observer, a three-dimensional electromagnetic disturbance appears as a wave (shaded) and as corpsucles where the vertical component intersects the observer's plane world.

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BOOKS AND THE SKY

ELEMENTS OF ASTRONOMY

Edward Arthur Fath. McGraw-Hill Book Co., Inc., New York, 1944. Fourth edition, 386 pages and charts. $3.00.

THE FIRST EDITION of this book appeared nearly 20 years ago. Many volumes of research publications have been placed on library shelves in that interval. Of all that vast effort, what, in the opinion of an outstanding teacher of astronomy, has meaning and significance for the elementary student?

Comparison of the new fourth edition with a much-worn first edition brought forth in answer to our question many interesting thoughts, some of which are noted below. Above all there was brought to mind, and forcefully indeed, the fact that a tremendous proportion of the research and thought of scientists reaches the multitude as a tiny paragraph or as a single sentence.

In Chapter I, the Introduction, are discussed the meaning of astronomy, the relation of astronomy to other sciences, and some practical aspects of the science. Evidently the author has grown dubious of relations between solar phenomena and weather since, in the fourth edition, this very practical possibility is relegated to fine print.

Chapter II, the Earth, and Chapter III, the Celestial Sphere, now appear in reverse order, a sequence which has definite advantages from a pedagogical viewpoint. Several sections on the earth's magnetism are added—excellent background for the same topic in relation to the sun.

In Chapter IV, Light, we observe the results of 20 years of scientific work. The Bohr theory of the atom has disappeared and in its stead is a section which certainly will not illuminate the situation as far as the elementary student is concerned. The problem of atomic structure and radiation is indeed a difficult one for the astronomy teacher, but, in our opinion, since it is of fundamental importance to astrophysics, it should be accorded adequate treatment, and not avoided. If the subject is not so treated in the astronomy class, an appropriate physics course should be a prerequisite. A desirable addition to this chapter is a discussion of the brightness of optical images.

Chapter V, which formerly included telescopes, spectroscopy, and auxiliary instruments, is now restricted to telescopes. Although hailed by many astronomers as a major instrumental advance of recent times, the Schmidt telescope is not mentioned, and the aluminizing of mirrors receives only a brief remark.

The striking similarity of Chapter VI, the Moon, in the two editions shows that acquisition of knowledge concerning our nearest neighbor proceeds at a snail's pace.

In Chapter VII, Problems in Practical Astronomy, there appears a marked change in subject matter doubtless stimulated by our present interest in navigation. One may wonder whether material on navigation is any more appropriate for an elementary text now than 20 years ago. Will it still be there when another 20 years have passed? The reviewer ventures to answer in the negative. Perhaps we shall be interested by that time in a new kind of navigation, that required in space rockets. If this be the case, the study of Gravitational Astronomy, Chapter VIII, will again become popular, and astronomy may be of some real use in this connection.

Combining the treatments of the Sun and Spectroscopy, as is done in Chapter IX, is a highly desirable change in the plan of the book. Recent work such as the Bethe theory of nuclear reactions, Edlen's identification of the coronal lines, and prominence studies at the McMath-Hulbert Observatory receive brief mention. The brevity of these remarks, and there are many additional instances, tends to reduce the general effectiveness of this text. Either the teacher must assume the burden of extensive explanations or the student will have gained from reading the text only fragmentary information and not a real understanding of subject matter or of the comparative importance of astronomical investigations. It is the reviewer's experience that a few topics taught thoroughly produce more satisfactory results than the brief enumeration of many topics.

As is to be expected, Chapter X, Eclipses, yields little new material on the mechanism of eclipses. Several new photographs improve the chapter generally. It is surprising to find the work of Lyot and the coronagraph mentioned only in a footnote.

Chapters XI, XII, and XIII, the Planetary System, the Terrestrial Planets, and the Major Planets, comprise a very satisfactory account of the solar system. Professor Fath's comments on such controversial subjects as the "canals" of Mars, the origin of the asteroids, the nature of Jupiter's red spot, are well chosen and presented in a reserved manner.

Chapter XIV, Comets and Meteors, while reflecting comparatively few advances in two decades, is one of the most interesting chapters in the book. Practically every aspect of these thought-provoking objects is touched upon.

The former two chapters on the Stars and their arrangement are now three, XV, XVI, and XVII. While retaining for the most part the same section headings, they give evidence of the vast amount of research completed in these

NEW BOOKS RECEIVED

PICTURE BOOK OF ASTRONOMY, *Jerome S. Meyer*, 1945, *Lothrop, Lee and Shepard.* 36 pages. $1.75.

An illustrated book on astronomy for young readers (about six to nine years old), concentrating mostly on the solar system.

fields. Some teachers may object to introducing the mass-luminosity curve before the student learns how the mass of a star is determined, but one must admit that the relation is an excellent illustration for the subject of absolute magnitudes.

The student who had read thus far in the author's first edition found that only three chapters remained—in the fourth edition there are five. Among the subjects now discussed at length, but which received scant attention 20 years ago, are the spectra of galactic nebulae, the Magellanic Clouds, absorption of light in space, the structure and rotation of the galaxy. Extragalactic systems are recognized for what they actually are, and an entire chapter deals quite thoroughly with their characteristics. The whole subject is climaxed by a chapter on the Visible Universe and its problems.

The last chapter (now XXII) on Cosmogony is most interesting. Two decades ago the first part of this chapter was devoted to a detailed explanation of the possible evolution of a star according to the Russell diagram. Just a hint was given that Eddington was making statements which, if true, would make a re-interpretation of the Russell diagram necessary. It appears that Eddington was right, for now quite a different story is told. However, in clearing up one point, astronomers have gotten into a new difficulty, namely the age of stars and the universe. The second big problem included in the last chapter was that of the origin of the solar system, and it still remains a big problem, with Lyttleton's double star theory a not too satisfactory advance. Nevertheless, Professor Fath appears optimistic about the possibility of a solution.

Notwithstanding the increase in the number of pages from 307 (first edition) to 386 (fourth edition) this book has decreased physically in size and mass. Shall we applaud on this occasion government restrictions? The publishers are to be congratulated on producing a book attractive in appearance and pleasing to hold and read.

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NOTES ON THE NATURE OF LIGHT

(*Continued from page 13*)

size have been called simple because they are formulated in terms of familiar concepts. As we move away from our size scale, we find laws of a different nature and, at first, we are not able to see them clearly. To make up for our limitations, we have assigned a statistical law which is always obeyed, the law of probability. This is the law that governs photon movement, atomic motions, electron behavior, and other phenomena of this world. Thus, we see that nature is not inherently more complex in her dealings with the atoms, but, because the microcosmos is so far removed from our size scale, we find the true laws more difficult to interpret.

When we magnify the laws of the atomic world and apply them to our size scale, they are in agreement with our observations. (It may be significant to note that when we minify the "simple" laws of our own size scale they do not apply to the microcosmos.) For example, there is no law in physics that prevents this magazine from suddenly flying out the window at a rate of half a mile per second. The average speed of the paper molecules is of about that value at room temperature, and, if all the molecules moved in the same direction at the same instant, the magazine would fly away. But, with the billions and billions of molecules in each sheet of paper, each molecule moving at random, probability tells us that the odds against such an alignment are so great that it will not happen during the life of our planet. As for the uncertainty in this example, the fuzziness is so small that for objects of our size scale, such as this magazine, it disappears altogether.

In our concluding discussion, next month, we shall consider the part played by the nature of light in problems of the macrocosmos: space and time of vast scale. The role of the velocity of light is exceedingly important in all problems concerning the size, structure, and evolution of the universe.

(*To be concluded next month*)

R.C.A.F. OPERATION "ECLIPSE"

(*Continued from page 4*)

visual examination of the paired spectra taken with cameras A and B, where the polarization was perpendicular to dispersion in one case and parallel in the other, seems to indicate some interesting results. The continuous spectrum of the corona shows up well on all spectra. On the direct exposures made with D, the corona is well photographed out to one solar diameter from the limb, and faint indications of a coronal streamer extend out to about two solar diameters. No long extended streamers were present, however.

As far as is known, the first photographs of an eclipse from over 30,000 feet and the first spectra taken from the air were secured in this operation.

Sincere appreciation is expressed to all those who helped make this operation a success, in particular, the Optics Division of the National Research Council, Ottawa, for assisting in the focusing and adjustment of cameras; Lt.-Comdr. D. H. Menzel, U.S.N.R., leader of the associated ground expedition to Bredenbury; Dr. R. W. Wood, Johns Hopkins University, the Polaroid Corporation, and the Eastman Kodak Company, for the loan of filters and gratings; and radio stations CJGX, Yorkton, CKY, Winnipeg, CKX, Brandon, and CBK, Watrous, for coming on the air early to aid in the navigation.

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From Start to Finish—11

By ALLYN J. THOMPSON

Further Equatorial Adjustment. On the following night, May 19th, we shall want to check the adjustments on another star, preferably one near the celestial equator. The choice of a star can be made by referring to the table on page 164 of the **Almanac** or paging through the tables on the apparent places of the stars in the **Ephemeris.** The simplest way is just to observe the evening sky at this season, whence it is seen that the 1st-magnitude star Spica, Alpha Virginis, is a good choice, and will transit about 9:30 in the evening, an hour before which time it is sufficiently dark to start working. Spica's declination is given as —10° 52'.

Choosing 8:30 p.m., May 19th, as our time for starting to work, we compute the meridian angle (negative hour angle) of Spica for that time. This will give its distance east of the meridian and enable us to predict easily the time it will cross the meridian. The methods employed are several, and known to most navigators. If the **Nautical Almanac** is used, the problem is simply to take out of the table on page 184, and the correction table on page 214, the Greenwich hour angle of Spica for May 20th at 1:30 Greenwich time. This value, subtracted from our longitude, tells how far Spica is east of our meridian. The GHA is found to be 59° 16'.1, and the meridian angle is 14° 30'.1.

The telescope maker, however, will do well to use the method whereby the local sidereal time is first computed (observatory clocks are made to run on sidereal time, making the computation unnecessary), and then the star's right ascension is subtracted from the sidereal time to give the hour angle. If the answer is negative, the star is east of the meridian an amount called the meridian angle, as already mentioned.

Page 2 of the **Almanac**, or page 8, last column, and Table II in the **Ephemeris**, are used. Spica's position is given on page 299 of the **Ephemeris** and page 184 of the **Almanac**, R.A. 13^h 22^m 18.7^s, Dec. —10°52'.6.

Sid. time 0^h G.C.T. May 19	15^h	45^m	$11^s.6$
20^h 30^m May 19	20	30	
Corr. for 20^h 30^m		+03	22.9
Long. corr. 4^h 55^m			+48.5
Sid. time 8:30 p.m. L.C.T.	12	19	23.0
Corr. standard time		+04	55.0
Sid. time 8:30 p.m. E.S.T.	12	24	18.0

Subtracting Spica's tabulated right ascension from this sidereal time gives us a meridian angle of 58^m east, so that Spica should transit 58 minutes after 8:30, or at 9:28 p.m. E.S.T.

Now aim the telescope so that the pointers read 11° south on the declination circle, and 58 minutes east of the meridian on the hour circle, and see if Spica is in the field at 8:30. Rotate the mount east or west on the wye to bring the star to a middle division of the field of view, while following it to culmination. At the moment of transit, 9:28 p.m., the hour circle is set to read 0^h, and the mount is tilted up or down, to bring the star to the center of the field. The declination circle is then set to 11° south.

Repeat the observations on Polaris on another evening, and again on a third star, one that is two or three hours east of the meridian. With patience, and if the mounting has been well built, it will be possible to bring the adjustments within the accuracy of the graduated circles.

Where possible, avoid stars having an altitude of less than 20°, as errors due to atmospheric refraction then become considerable, and must be taken into account. Therefore, those amateurs residing in low latitudes should apply a correction for refraction when making adjustments with Polaris. This correction, to be subtracted from the observed altitude of a star, can be taken from Table A in the **Nautical Almanac.**

When the adjustments have finally been completed, sidereal time can then be found without computation by observing the transit of any celestial object, the right ascension of which is known. Its right ascension is, at the moment of transit, equal to the local sidereal time. Or, at any time, center the object in the field of view, and note the hour angle as read by the indicator. Adding this to or subtracting it from the right ascension of the object, depending on whether it is west or east of the meridian, will give the local sidereal time. It will be found more convenient, however, to set a spare timepiece, and to keep it running on sidereal time on nights of observation.

The **Nautical Almanac** and the **Ephemeris** explain the method of finding sidereal time, but for a more complete study of the various kinds of time, the reader is advised to consult a standard astronomy or navigation text.

To find the watch time of meridian transit of the sun, in order to locate true north by day, we must know the exact longitude. This can be found with sufficient accuracy from maps of the U. S. Coast and Geodetic Survey. The equation of time, that difference between the sun and the clock which is caused by the ellipticity and inclination of the earth's orbit (as referred to the equator), is taken from the **Almanac** or the **Ephemeris** for the date and hour of Greenwich time, and applied with its sign reversed. Noon at any place occurs at 12:00, local apparent time.

For example, to find the watch time

EDITED BY EARLE B. BROWN

of transit of the sun on April 28, 1945, at a place in longitude 73° 46′ 12″ west:

L.A.T. of L.A.N.	12^h	00^m	00^s
Eq. of time, 17:00 G.C.T.		—02	33
L.C.T. of L.A.N.	11	57	27
Corr. stand. time		—04	55
Watch time, L.A.N.	11	52	32

Set up a plumb line over the pier, and mark the direction of its shadow at the moment of local apparent noon. This will be a true north-south line. The watch will, of course, have been accurately set by radio time signal.

XII — CONCERNING ATMOSPHERE

The chief hindrance to the use of high magnifying powers is atmospheric disturbance. The atmosphere consists of layers of air of different temperatures and densities, and different refractive indices. These layers stream along, like vast rivers, smoothly or rippling, and in different directions, sometimes rising, sometimes descending. When the telescope is pointed skyward, the starlight which enters it has been buffeted about on its passage through these strata. This buffeting is what causes the star to twinkle. The condition is made worse if the star's altitude is low. Local topography, adjacent mountains, woodland, and the presence of large bodies of water influence these turbulences, which may change from hour to hour. Some localities have a larger annual percentage of nights when the atmosphere is stable, and the seeing is good, than others. Such places are preferred as sites for observatories. In the arid regions of the west, for example, large telescopes will perform better than along the Atlantic seaboard, where the seeing is not so good. But even the poorest regions in this respect have occasional nights when the atmosphere seems to be perfectly still, and the highest magnifications can be enjoyed. Along the seaboard, nights when the sky is slightly hazy are generally excellent for the use of high powers. The clear, "sparkling" nights of winter are frequently poor.

Both refractor and reflector are subject to these disturbances, and there is nothing that can be done about them. But the reflector has the disadvantage of thermal disturbances inside its open tube. How to control these effectively has long been a problem. Heating units, mechanical ventilation, insulation, and other improvements have been tried with considerable success. If the tube is of metal, it should be thoroughly insulated with sheet cork, of at least ⅛″ thickness.

Fig. 45. How the sheet cork lining is fitted inside the tube.

Properly installed, the sheet cork lining should be made to hold itself by compression inside the tube, without need for retaining rings. Therefore, the width to which the sheets should be cut must be carefully predetermined. Consider the case of lining an aluminum tube 56″ long, outside diameter 7″, wall thickness 1/16″, with sheet cork ⅛″ thick. The inner circumference of the tube is 21.6″, and when lined, this will be reduced to 20.8″, which would suggest that the width of the sheets ought to lie somewhere between these two figures. By experiment with a scrap length of the material, it is found that

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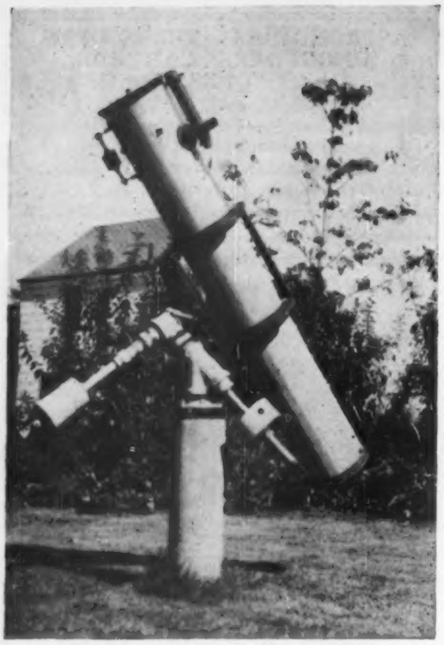

Fig. 46. An 8-inch f/8 Newtonian, with babbitted bearings. Axes of 1½" (pipe size) shafting; 10" tube of 22-gauge sheet metal; saddle and rotation rings of aluminum. Rigid and perfectly balanced, this telescope responds to finger-tip control.

a snug fit is effected with a width of 21 5/16". Accordingly, two sheets of cork, one 37" long, and the other 19" long, are cut to this width. Locate and cut out holes for the spider arms, eyepiece opening, and so forth, and paint dead black the surfaces to remain exposed. The sheets are then bent into a rounded sort of "W" shape and pushed into the tube with the edges brought together in a butt joint, leaving a bulge opposite, as in Fig. 45; this bulge is then carefully pressed out.

The telescope should be brought outdoors at least an hour before use, to allow the mirror sufficient time in which to adapt itself to the change in temperature. Cold air suddenly coming in contact with the mirrors may cause dewing. The eyepiece may also become dewed. The moisture will evaporate in a short while, but if it is desired to remove it immediately, mop it up carefully with a clean soft cloth, or dirt particles on the surface may cause scratches. The lower end of the tube should have vents to permit the free passage of air, and to allow any heat to escape from the mirror.

One form of disturbance is air flowing along the walls of the tube, similar to the way in which tobacco smoke creeps along a table top. Much or all of this can be kept out of the field by making use of a tube that is two, or even three inches greater in diameter than the mirror. An annulus having a 7" aperture should be fitted to the open end of such an oversize tube, serving to cut off extraneous light as well as to retard the flow of air. Two or three narrow rings, spaced at intervals inside the tube, not so wide as to interfere with the light, help to arrest this flow. These rings perform the added function of breaking up the reflection of oblique rays which a smooth surface, no matter how well blackened, cannot completely absorb.

Emphasis has long been placed on the necessity of ventilating the mirror end of the tube at all times. The 8-inch telescope shown in Fig. 46 has a tight-fitting cover at that end, which is removed late in the day to permit ventilation, and is replaced just before observing. Numerous trials have shown that the air inside the tube is steadiest when the tube is covered. The 4¼-inch f/4.5, pictured in Fig. 43, is permanently closed up at the mirror end, and observations with it are always excellent. Of course, magnifications of 10 per inch of aperture are the highest ever used with it.

When using high-power eyepieces in an absolutely steady atmosphere, one or two diffraction rings, broken up by the spider vanes, may possibly be seen surrounding the disk of a 1st- or 2nd-magnitude star. This will be a rare occasion, but they should be watched for, as they are an interesting phenomenon, and are also indicative of the quality of the mirror. Except when the air

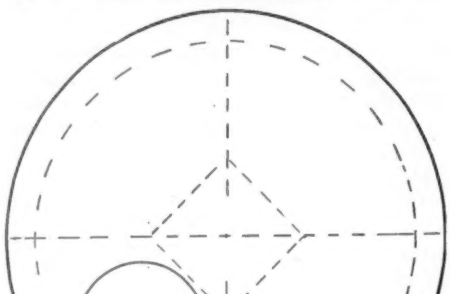

Fig. 48. The offset diaphragm.

is greatly disturbed, they can be seen by diaphragming the mirror down to about 2" in diameter, using an offset diaphragm like that in Fig. 48 over the open end of the tube. It then becomes, in effect, a 2-inch telescope of f/24 ratio, and as there is no interference from the spider, the definition should be beautiful, the same as obtained with a

Fig. 47. Featherweight Newtonian, 3-inch f/4. Pipe fittings and bearings are similar to those in Fig. 38.

refractor of similar proportions. At least one diffraction ring will nearly always be seen surrounding the image of a 1st-magnitude star.

It may be noticed that this image, or diffraction disk, is larger than it appears to be when the star is viewed with full aperture. That is precisely the case, as the angular diameter of the disk is inversely proportional to the diameter of the mirror and is independent of the focal length. The size of this disk also places a limit on the resolving power of the telescope, that is, the least separation of two stars that may be seen as double with it. This is called Dawes' limit, and is given by the equation: $d'' = 4''.56/a$, where a is the aperture in inches. This is .76 seconds of arc for a 6-inch telescope. If the resolving power of the eye is put at 4 minutes of arc, 320 power is required to take advantage of the resolving power of the mirror. However, the moderate focal length of the f/8 limits its highest magnification to about 200, and the least separation to about 1".2.

If the eyepiece is moved inside or outside of focus, a half dozen or more rings may be seen, looking somewhat like a reverse appearance of Fig. 23b. The steadiness of these rings will reflect the stability of the atmosphere, and when properly interpreted, as seen when using the full aperture, they will disclose zonal errors and any undercorrection or overcorrection present in the mirror.

Use of the diaphragm should improve the seeing, due to the smaller aperture and to partially sealing off disturbances inside the tube. Compare views of the moon and planets as seen with it and with the whole mirror; also try it for terrestrial observation by day.

For a thorough discussion of atmospheric effects, seeing, diffraction-ring patterns, and so on, see **The Telescope**, by Bell, and **Amateur Telescope Making Advanced**, Scientific American Publishing Co.; also see **Telescopes and Accessories**, Dimitroff and Baker, Blakiston.

(To be concluded next month: In Defense of the Reflector)

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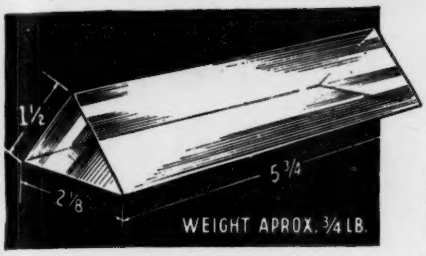
UNUSUAL WAR BARGAINS in LENSES and PRISMS

TANK PRISMS



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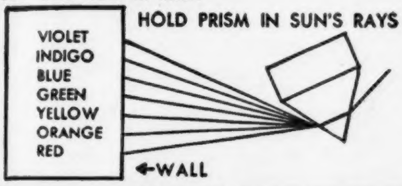

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6078-Y*	33	140	Uncemented	70c
6081-Y*	35	55	Uncemented	70c
6082-Y*	37	57	Uncemented	70c
6084-Y*	41	66	Uncemented	70c
6085-Y	45	135	Uncemented	$1.00
6086-Y*	49	75	Uncemented	90c
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OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

OCCULTATION PREDICTIONS FOR SEPTEMBER

THIS MONTH is noteworthy for the many and favorable occultations visible to observers in North America. They occur chiefly when the moon passes through Sagittarius on the 15-16th, and when, near last quarter, it covers bright stars in Taurus and Gemini from the 25th to the 29th. On September 25-26th, several stars in Taurus are occulted in rapid succession. On the 27-28th, the moon covers Eta Geminorum, one of the bright stars in Castor's foot, and several other stars, some of which are included in the following list of selected occultations. For suggestions on the use of this information, especially by observers far from standard stations, see the article in the July issue.

15-16 *24 Sagittarii* 5.7, 18:30.5 —24-04.5, 9, +66° +5° Im: *A* 23:00.5 —2.2 +1.0 61°; *C* 22:46.3 —2.3 +1.1 71°; *E* 22:19.9 —1.6 +1.2 83°; *F* 22:02.9 —0.9 +0.1 116°.

15-16 *25 Sagittarii* 6.4, 18:31.2 —24-16.0, 9, +66° +19° Im: *A* 23:21.8 —2.0 —0.1 103°; *C* 23:12.8 —2.0 —0.1 111°; *E* 22:48.9 —1.3 +0.2 120°; *F* 22:49.5 —0.1 —2.4 159°.

17-18 *36 B Capricorni* 6.2, 20:26.3 —22-34.5, 11, +68° +19° Im: *A* 23:55.7 —1.8 +0.7 92°; *B* 23:56.1 —1.6 —0.8 88°; *C* 23:45.2 —1.7 +0.7 98°; *E* 23:26.5 —1.1 +0.9 103°; *F* 23:18.3 —0.4 —0.7 137°.

18-19 *128 B Capricorni* 6.5, 21:26.9 —19-23.3, 12, +71° +5° Im: *A* 1:42.4 —1.6 +1.1 51°; *B* 1:44.3 —1.4 +1.1 45°; *C* 1:30.6 —1.8 +1.3 53°; *D* 1:33.3 —1.5 +1.4 44°; *E* 1:09.2 —1.5 +1.8 47°; *F* 0:41.5 —1.4 +1.5 69°.

19-20 *56 Aquarii* 6.4, 22:27.3 —14-52.1, 13, +72° —5° Im: *A* 3:44.9 —1.0 +1.2 31°; *C* 3:34.9 —1.2 +1.5 32°; *E* 3:23.0 —0.7 +2.8 6°; *F* 2:48.3 —1.4 +2.5 27°; *H* 2:43.8 .... 354°.

24-25 *3 B Tauri* 6.4, 3:08.3 +12-50.4, 18, +90° +22° Em: *A* 3:47.1 —0.1 +2.4 204°; *B* 3:54.0 —0.2 +2.3 212°; *C* 3:38.4 +0.1 +2.5 203°; *D* 3:49.1 —0.1 +2.1 215°; *E* 3:41.3 +0.1 +2.0 220°.

25-26 *180 B Tauri* 6.2, 4:04.8 +17-11.7, 19, +90° +20° Em: *A* 3:11.6 0.0 +1.8 236°; *B* 3:16.7 0.0 +1.7 241°; *C* 3:06.0 +0.2 +1.7 234°; *D* 3:14.0 +0.1 +1.6 243°.

25-26 *85 H[1] Tauri* 6.0, 4:17.2 +18-36.7, 19, +55° —15° Em: *A* 9:57.8 —1.9 —0.8 276°; *C* 9:50.5 —2.0 —0.1 266°; *D* 9:43.0 —2.1 —1.0 285°; *E* 9:19.6 —2.4 —0.4 286°; *F* 9:01.3 —2.1 +0.8 264°.

25-26 *234 B Tauri* 6.0, 4:21.7 +18-55.0, 19, +53° —17° Em: *A* 12:26.3 —0.9 —1.7 282°; *C* 12:26.1 —1.2 —1.0 267°; *E* 12:05.0 —1.7 —0.8 270°; *F* 11:50.4 —2.1 +1.1 237°; *H* 11:04.2 —2.5 —0.2 282°.

25-26 *Epsilon Tauri* 3.6, 4:25.4 +19-03.6, 19, +58° —13° Im: *E* 12:50.8 —1.4 —0.5 77°; *F* 12:50.8 —2.0 —2.2 115°; *G* 12:25.5 —1.1 +2.1 30°; *H* 11:56.7 —2.1 +0.7 76°; *I* 12:12.5 —1.0 +2.5 28°.

26-27 *o Tauri* 4.8, 5:24.3 +21-53.5, 20, +50° —14° Im: *E* 12:17.5 —1.9 +1.0 58°; *F* 11:58.9 —2.5 —0.2 92°; *H* 11:20.2 —1.3 +2.2 49°. Em: *E* 13:29.6 —1.4 —1.7 288°; *F* 13:24.3 —2.1 +0.3 249°; *H* 12:34.7 —2.4 —0.2 279°.

27-28 *Eta Geminorum* 3.2-4.2, 6:11.6 +22-31.5, 21, +90° +22° Im: *A* 5:42.4 —0.8 +0.5 120°; *B* 5:43.7 —0.6 +0.9 110°; *C* 5:37.5 —0.8 +0.2 124°; *D* 5:39.0 —0.4 +0.9 108°; *E* 5:33.3 0.0 +0.9 103°; *F* 5:28.1 0.0 +0.1 120°. Em: *A* 6:29.1 0.0 +2.8 216°; *B* 6:36.5 —0.2 +2.4 226°; *C* 6:19.4 +0.2 +2.9 212°; *D* 6:31.3 —0.1 +2.3 229°; *E* 6:24.1 +0.1 +1.9 235°; *F* 6:07.0 +0.7 +2.1 217°.

28-29 *58 Geminorum* 6.0, 7:20.2 +23-03.2, 22, +61° 0° Em: *A* 11:58.8 —2.0 —0.3 273°; *C* 11:48.5 —2.2 +0.6 259°; *E* 11:20.7 —1.9 +0.9 265°; *F* 10:51.7 —1.3 +2.6 233°; *G* 10:48.0 —1.4 —0.7 321°; *H* 10:36.7 —0.9 +0.9 278°; *I* 10:36.1 —1.5 —1.2 330°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, G.C.T., **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

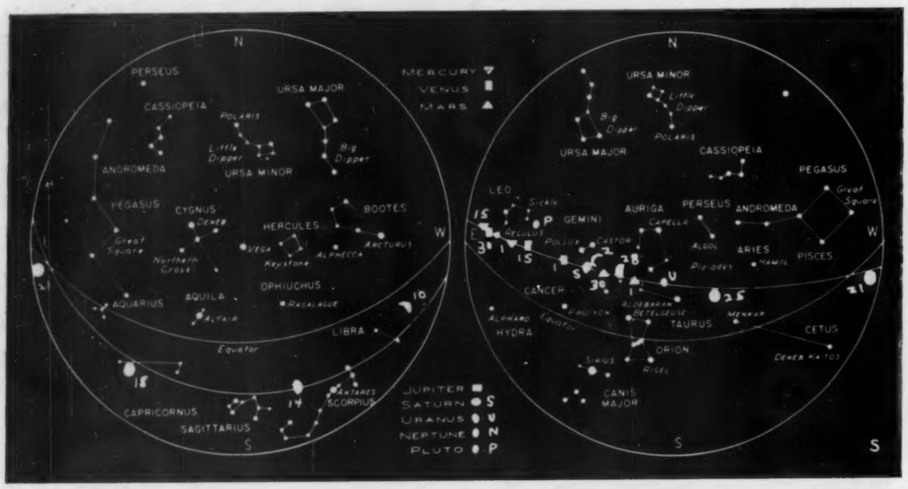
Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**B** +73°.6, +45°.6
C +77°.1, +38°.9	**D** +79°.4, +43°.7
E +91°.0, +40°.0	**F** +98°.0 +30°.0
G +114°.0, +50°.9	**H** +120°.0, +36°.0
I +123°.1 +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the **difference in longitude (Lo — LoS)**, and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard or war time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury reaches a very favorable greatest western elongation on the 6th of the month, when it rises an hour and a half ahead of the sun, and is about 18° above the horizon at sunrise in latitude 40° north. For a week before and two weeks after the 6th, Mercury should be easy to find, for its stellar magnitude is zero.

Venus remains the brightest object in the morning sky, passing close to Regulus on the 23rd. It is 2½° south of the moon on the morning of the 3rd, at 6:41.

Earth reaches heliocentric longitude 0° on the 266th day of the year, September 23rd, at 5:50 a.m., and autumn begins in the Northern Hemisphere, spring in the Southern.

Mars rises about midnight and is becoming more conspicuous among the stars in Taurus and Gemini. Early on the evening of the 28th, at 7:39, it is in conjunction with the moon, the geocentric separation being only 12′, but at this time the moon and Mars are on the meridian in longitude 100° east of Greenwich. The resulting occultation is invisible in the Western Hemisphere.

Jupiter is too close to the sun for observation.

Saturn rises from two hours to about an hour later than Mars, and is in Gemini, its magnitude now being 0.4.

Uranus is in Taurus, at $5^h\ 05^m$, +22° 52′ on the 15th. It commences retrograde motion on the 23rd.

Neptune is too close to the sun for observation.

PHASES OF THE MOON

New moon......	September 6, 9:43 a.m.
First quarter ...	September 14, 1:38 p.m.
Full moon	September 21, 4:46 p.m.
Last quarter ...	September 28, 7:24 a.m.

IN THE MOON'S SHADOW

(*Continued from page 9*)

ley on Sunday afternoon just in time to join in the multitudinous snapshotting of group pictures at the mayor's reception. This was a most enjoyable occasion.

The Texas party met us at the hotel at 4 a.m., and dawn was well ahead when we set out for our site; the air was decidedly chilly though there was very little wind, and the dew was heavy on the grass. Arriving, we found Fred Falk and party already astir, and it did not take us long to set up our three cameras, firmly clamped to tripods. About 15 minutes before totality the sun passed into perfectly clear sky.

Now all was in an eerie light; the crescent was getting thinner and thinner; then, just for a second or two, Baily's beads; then, in a flash, appeared the great spectacle! The jet black disk, the pearly corona streaming east and west, a diameter and a half out from the sun, in feathery luminescence, all set in a turquoise blue background. It was difficult to turn from the scene and attend to the well-rehearsed tripping of camera shutters, but in hasty orderliness that was done, and a fleeting few seconds remained.

As we all returned to the Wolseley hotel our cup of happiness at having had such perfect conditions was full and running over.

CARL P. RICHARDS
Salem, Ore.

FROM ILLINOIS. Three members of the Popular Astronomy Club of Moline, Ill., Carl H. Gamble, president, R. S. Young, secretary-treasurer, and Dan Dahlen, former vice-president, made the trip to Wolseley, driving out from Regina on Sunday morning in a pouring rain, which made our spirits as gloomy as the weather.

We stopped at the schoolhouse and had a chance to look over the expedition equipment and hear something of the method of operation. They told us that continuous weather reports indicated prospects of a clear sky. Our site we selected at a crossroads about a quarter of a mile farther on, on a slight elevation with an unobstructed view of the horizon, and drove back to Regina in a more optimistic frame of mind than on our way out.

Up at 2:00 a.m. on July 9th, we arrived at the observing site thoroughly chilled, and got our binoculars and smoked glasses ready in time for sunrise. The temperature being 42°, we did an occasional hundred yards up and down the road to keep our blood in circulation, and were just about ready to trade a slice of the eclipse for a good thermos of hot coffee.

Intently watching. we were still unprepared for the dazzling spectacle that flashed before our eyes at the moment of totality. We stood spellbound and motionless. A fleeting glimpse of Baily's beads, and in the twinkling of an eye we were back again on this mundane sphere, wondering if the corona had been just a figment of imagination.

On the way from Winnipeg to Regina, in Regina and Wolseley, and on the way home, we had very pleasant exchange of ideas with the many other amateurs we encountered, and we plan to keep in contact with each other in the interest of astronomy.

R. S. YOUNG
Moline, Ill.

A PINE RIVER REPORT. For a few nights prior to the eclipse, we had grand displays of the aurora, largely aquamarine, though I saw some rose tints.

I took with me a 3-inch refractor, focal length 42 inches, with a tube attachment for my Korelle Reflex, without ocular or camera lens. At the far end of the ocular tube I had a cell into which I had fitted an Eastman series 25 red filter, removable, which had a factor of 8 with the Ansco Supreme film used. Prior to totality, I was using a stop over the objective to reduce it to one inch.

Thirteen pictures in all were taken, only two during totality, one of which has a tremendous flare, presumably due to Baily's beads. Though two large prominences were seen in very rapid motion, I did not find anything spectacular regarding these on my films. None of my partial phase pictures shows any sign of the four sunspots that others saw.

Prior to totality, all exposures were at my maximum of 1/500 second and with the stop. During totality, I removed the stop and took at 1/50 second with the red filter in. It was impossible to find time to remove the filter to photograph the corona. The whole thing seemed like 10 seconds!

L. T. S. NORRIS-ELYE
Winnipeg, Man.

MINIMA OF ALGOL

Sept. 1, 10:22 p.m.; 4, 7:11 p.m.; 16, 6:25 a.m.; 19, 3:14 a.m.; 22, 0:03 a.m.; 24, 8:51 p.m.; 27, 5:40 p.m.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium, 81st Street and Central Park West, New York City, and of the Buhl Planetarium, Federal and West Ohio Streets, Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents *September 4-30,* THE MYSTERY OF THE NORTHERN LIGHTS.

Few spectacles of the night sky equal in interest or beauty the northern lights—the aurora borealis. For the scientist it is a phenomenon of deep-seated importance, since there is a connection between the aurora and the occurrence of sunspot cyclones on the sun, as well as weather changes on the earth. Special optical apparatus adds the aurora to the Planetarium heavens—a truly spectacular display such as few persons are ever likely to experience in the real sky.

★ **THE HAYDEN PLANETARIUM** presents in *September,* TRIP TO THE MOON.

In *October,* AUTUMN SKIES. The constellations are composed of individual stars with varying characteristics. What do their colors mean—red, green, yellow, blue? Why do stars sometimes explode? Stars come in pairs, in triplets, quadruplets, multiple families. Constellations are apparent, not real, groupings. Learn about the "apparent" as distinguished from the "real" characteristics of the stars and constellations.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays	3 and 8:30 p.m.
Sundays and Holidays	3, 4, and 8:30 p.m.

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Manager,* Frank S. McGary; *Public Relations,* John F. Landis; *Chief Instructor of Navigation,* Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation,* Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays	2, 3:30, and 8:30 p.m.
Saturdays	11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays	2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Associate Curator,* Marian Lockwood; *Assistant Curator,* Robert R. Coles; *Scientific Assistant,* Fred Raiser; *Lecturers,* Catharine E. Barry, Shirley I. Gale, John Saunders, Robert Snedigar.

DEEP-SKY WONDERS

AMONG marvels for observation in the September skies are the objects listed here, some of which are not shown on the chart above. The informal descriptions are for common telescopes.

Corona Australis. NGC 6541, 18^h $4^m.1$, —43° 44′; globular, 6′.3 in diameter.

Sagittarius. M28, 18^h $21^m.2$, —24° 54′; globular, dim, fuzzy, 4′.7. Three small globulars: M69, 18^h $27^m.7$, —32° 23′; M70, 18^h $39^m.6$, —32° 21′; M54, 18^h $51^m.6$, —30° 33′.

Capricornus. M30, 21^h $37^m.3$, —23° 26′; globular, 5′.7. In large amateur telescopes it seems to be on starry stilts.

Aquarius. NGC 7293, 22^h 26^m, —21° 07′; largest planetary, called the Helical. Very dim, best seen in the finder or with low power.

L. S. COPELAND

STARS FOR SEPTEMBER

from latitudes 30° to 50° north, at 10 p.m. and 9 p.m., war time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

EVENING STARS FOR SOUTHERN OBSERVERS

THIS is the eighth map in the series of star charts for use by observers in the Southern Hemisphere, and matching the northern maps. It is prepared for a basic latitude of 30° south, but may be used conveniently 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. When 12 charts have been produced, and if interest warrants, a special edition of **Sky and Telescope** may be published each month carrying observing material for Southern Hemisphere observers. This chart is for use in latitudes 20° to 40° south on November 7th at 11 p.m., November 23rd at 10 p.m., Dec. 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly: four minutes earlier per day. These are local mean times which must be corrected for standard time and war time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts.